



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE EFFECTS OF CASTRATION OF HEN- FEATHERED CAMPINES.

T. H. MORGAN.

In the Sebright Bantam I have shown (1913, '15, '17, '19, '20) that castration changes the hen-feathered male into a cock-feathered bird. There is only one type of male in the Sebright race—the hen-feathered bird. In a few other races of poultry, two kinds of males are known, one hen-feathered, the other cock-feathered. Both are fertile, and sometimes one type is recognized as the standard, at other times and places the other type. It is very probable, from evidence that will be given later, that the hen-feathered Campine type is dominant over the cock-feathered. This explains why it is more difficult to find a race pure for hen-feathering; because both the males and the females of such a race may carry the recessive factor for cock-feathering. It is known that many of the stocks, supposed to be hen-feathered, occasionally “throw” cock-feathered males. Now that the cause of this “reversion” is understood, it should not be difficult to produce a race pure for hen-feathering. In fact, even the ordinary way of breeding, if combined with a strict selection, would in time bring about such a result.

For several years I have been desirous of performing on such a dimorphic race as the Campines the same castration experiment that had been successful in the Sebrights; but it was essential to find first a stock that was pure for hen-feathering. Fortunately the stock of Mr. Martling of Ridgefield, N. J., appears to satisfy this condition. I have seen the birds in his flock for three years, and in one year all of the juvenile cockerels before any selection amongst them had been made. They were all hen-feathered with the rare exception of a male that had “broken,” in the sense that a few feathers were changed in the direction of cock-feathering. The history of one such bird, to be described below, shows that the occurrence of these “breaks” does not prove the impurity of such stocks. The statement of Mr.

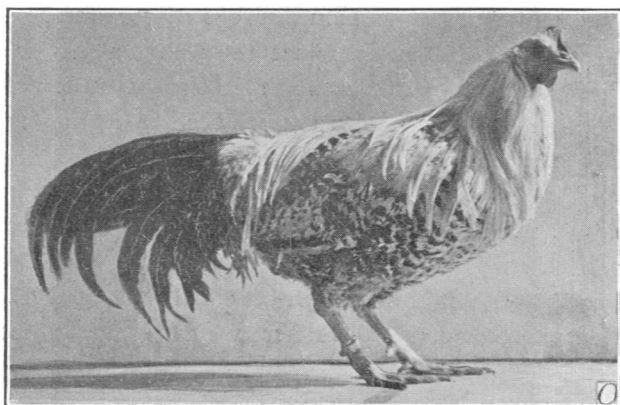
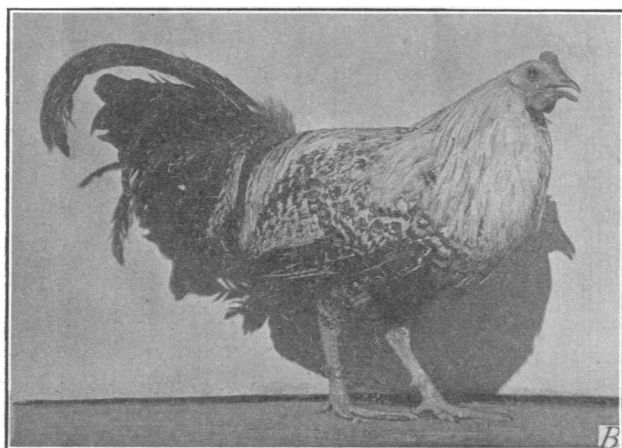
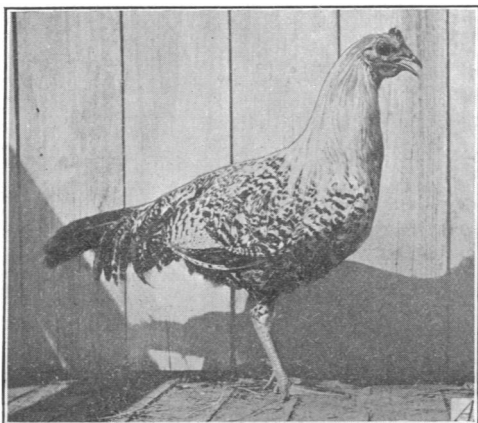


FIG. 1. Youngest bird (castrated June 16); *A*, as it appeared on Sept. 9; *B*, on Nov. 12, 1919; and *C* on Apr. 16, 1920.

Martling that such birds later become hen-feathered is further and important evidence on this point.

In May, 1919, I obtained three young cockerels that had hatched about the first of March, 1919. The youngest had hatched a week later than the other two, and was still in its juvenile plumage, although feathers of the next plumage were just beginning to push out. The bird still peeped. The other, larger birds had just begun to crow and had some of their secondary plumage fairly well developed in critical regions of the body (back, saddle), and this showed definitely the hen-feathered condition. These two birds were castrated on June 16, 1919. The testes of both were in the juvenile condition, and were readily removed, although a piece of one testis of the larger bird broke off and its complete removal was indicated as doubtful. Typical feathers from each of these birds are shown in Fig. 2, *a*, *b*, *c*, *d*, Fig. 5.

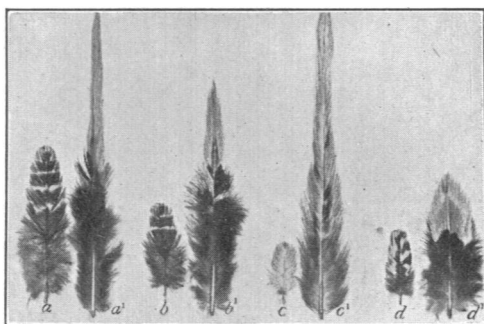


FIG. 2. Feathers of same bird (Fig. 1); *a*-*d*, before, and *a*¹-*d*¹, after castration, Nov. 13.

a, *b*, *c*, *d*. As the new feathers came in during the following weeks and months they showed clearly the effects of castration; that is, they were cock-feathered or strongly marked in that direction. The younger bird had just begun to develop its second plumage, and as the feathers continued to appear, the first of them were hen-feathered in pattern and in shape at the tip of the feather, while the base only was affected by the castration and showed some of the characters of cock-feathering. These results go to show that the young bird also would un-

doubtedly have been hen-feathered if it had not been castrated. Further details concerning these two birds are seen in the photographs of the birds and of their feathers. The appearance of the castrated "younger" bird on September 9, may be gathered from Fig. 1, *A*.

He was obviously becoming cock-feathered at this time, but the change was not as great as it became later. The juvenile feathers present on June 16 (at the time of operation,) are shown in Fig. 2, *a, b, c, d*. The changes that had taken place by Novem-

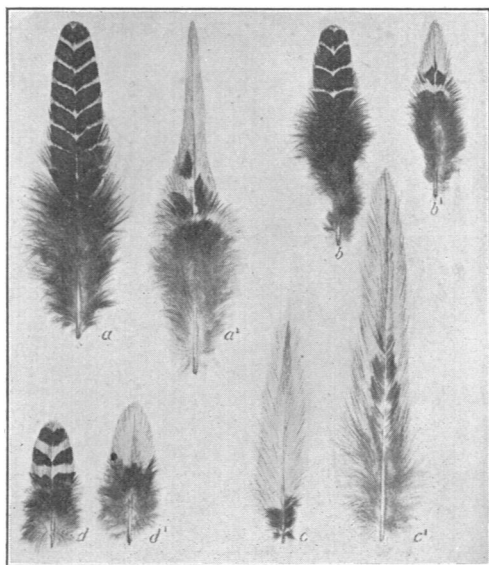


FIG. 3. *a, b, c, d*, feathers of adult hen-feathered Campine (Fig. 8, *A*), and *a¹, b¹, c¹, d¹*, those of Fig. 1, *C*, March 13.

ber 12, are shown in the photograph of the bird (Fig. 1, *B*) and in the pictures of the feathers (Fig. 2, *a¹, b¹, c¹, d¹*.) The last picture of this bird was taken April 16, 1920 (Fig. 1, *C*). The picture shows the long, white neck-feathers, that are almost white. The long, white saddle feathers are also well shown in the photograph. The tail coverts and the sickle feathers are very long and the upper ones are black. Later the sickles became even longer. The white shoulder feathers can be seen through the neck hackles. The details of the feathers are better shown in

Fig. 3, a^1 , b^1 , c^1 , d^1 , where they are accompanied by feathers from the same region of an adult hen-feathered Campine (Fig. 3, a , b , c , d). Taking these in pairs we see that the beautiful barring of the saddle feather (Fig. 3, a) gives way in the castrated

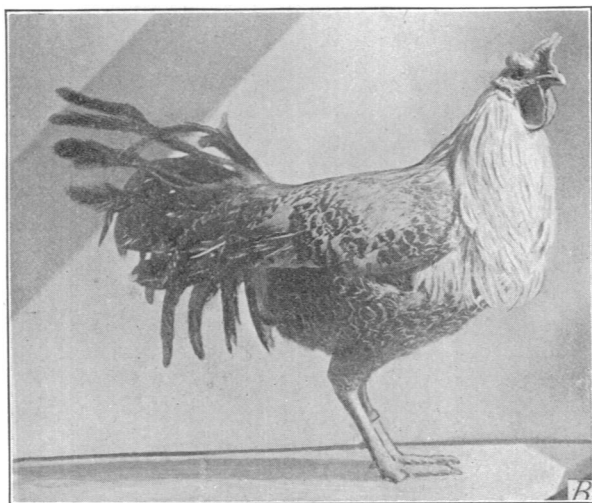
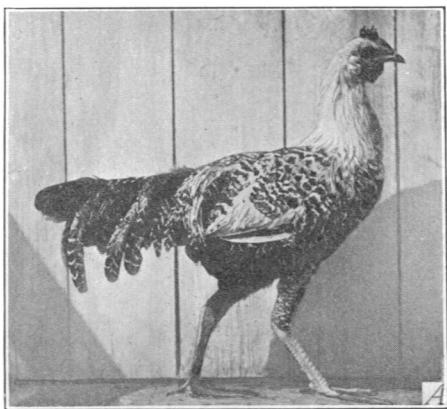


FIG. 4. Second "larger" bird castrated June 16, 1919. *A*, as it appeared Sept. 9; and *B*, as it appeared March 2, 1920.

bird to a pointed white feather, black only at its base (Fig. 3, a^1). The sides of the outer portions of this feather lack barbs as in the common cock. The feathers of the back of the hen-

feathered male are also barred; this too is lost after castration (Fig. 3, *b*, *b*¹), when the tip becomes white, more pointed, and hackled. The change in the neck feathers (Fig. 3, *c*, *c*¹) is not so striking because they are already somewhat elongated and white as in the hen, but after castration they increase greatly in length, more in fact than shown by the feathers in the pictures.

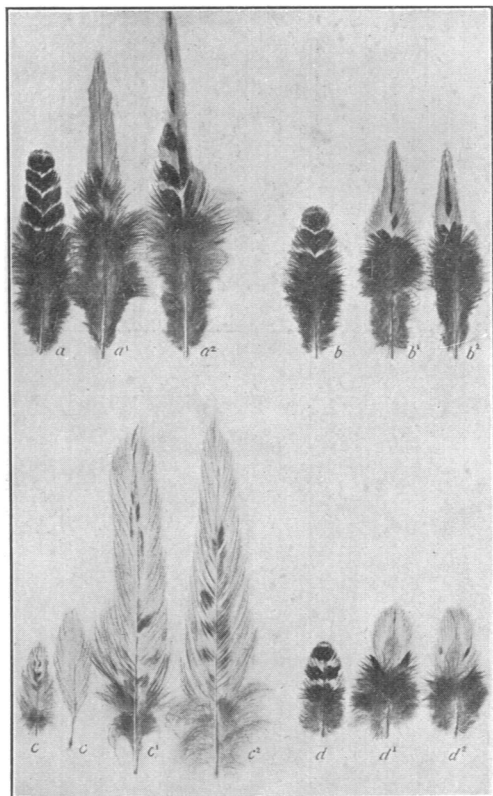


FIG. 5. Feathers of Fig. 4, *a*, *b*, *c*, *d*, before castration, and *a*¹, *b*¹, *c*¹, *d*¹, after castration on Sept. 15, and *a*², *b*², *c*², *d*², on March 3, 1920.

The feathers of the shoulder (wing-bow), of the hen-feathered male are barred with broad bars, Fig. 3, *d*. After castration the barring is lost, the outer ends of the feathers become pure white, and on each side barbs are lacking over a broad zone. This change, also, is towards cock-feathering as seen by comparing

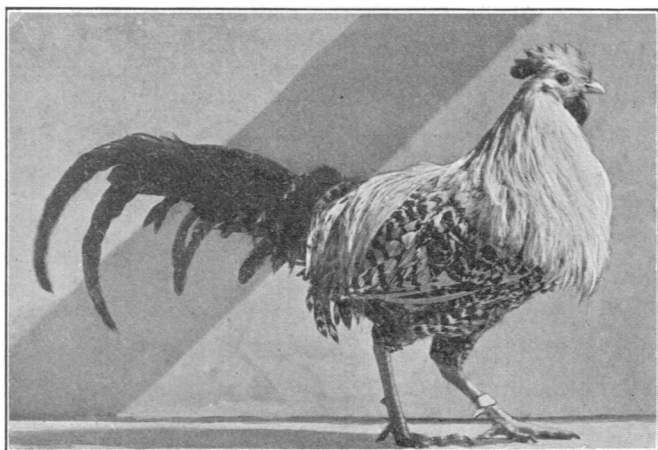
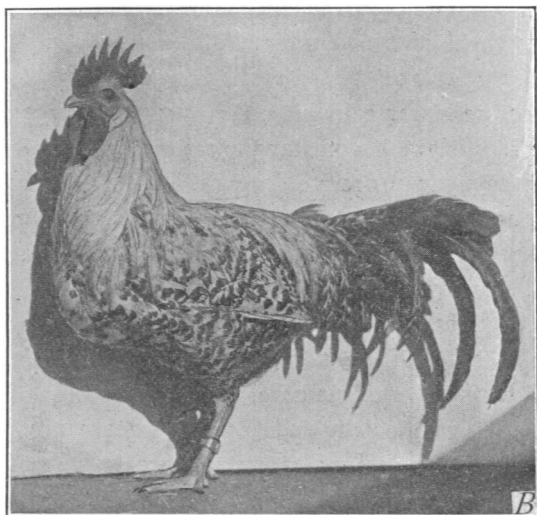
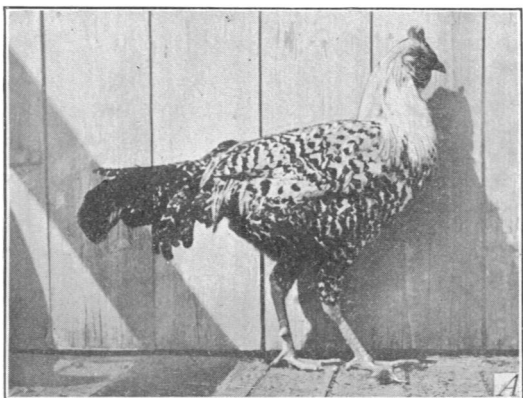


FIG. 6. *A*, third Campine that showed in its first adult feathers indications of cock-feathering, Sept. 9. Castrated Sept. 13. *B*, as it appeared Nov. 12; and *C*, as it appeared on March 6, 1920.

Fig. 1, C, with that of the cock-feathered Campine in Fig. 9. The bird was killed May 9, 1920. On the right side in the position of the testis there was found a very small piece of testicle-like tissue. In addition there were two sacks filled with black matter, attached loosely to the mesentery near the old position of the testis.

In this "small" Campine a piece of testis was found, as stated, in the situs of the removed testis. The histological structure of this regenerating testis is entirely similar to that in the regenerating piece of the Campine that was castrated when cock-feathers were beginning to appear. The description of the latter may serve for that found in the small Campine; both pieces agree in all details: the luteal cells have disappeared entirely and large numbers of small lymphocytes are produced in the mesenchyme. The spermatogenetic process is normal in the tubules that had been left, but the spermatozoa are degenerate. New seminal tubules are arising, but they are reduced to the Sertoli cells, no spermatogonia being present.

Besides this piece of regenerating testis there were found dark masses of tissue. In these masses there has been an active proliferation of connective tissue cells, which form strands placed in all directions. Some of the cells in this stroma are filled with large drops of a fat-like substance. There is an active hematopoiesis in these masses, the large lymphocytes being abundant, both within and outside the blood vessels. Large accumulations of normal and degenerated erythrocytes occur in the blood vessels, hence the dark color of the masses. The aspect of the latter suggests that they are portions of the degenerated epididymis, a few tubules of the latter being present, although their epithelium is almost entirely degenerated.

The extent to which the second "larger" bird had changed by Sept. 9, is shown in Fig. 4, A. His new back and saddle feathers were long and pointed. He continued to become more cock-feathered, but his comb began to grow, and it became evident that some of the testis had been left. He was opened under ether. Attempts were made to remove the pieces, but the operation was not successful as shown by the condition of the comb which remained large. It was however very pale. The bird

was in such poor condition after the second operation that for a time it was expected that he would die, but he finally got better and lived several months. When the bird was killed a large growth of bony substance was found on the left femur that fitted into a deep depression in the ribs. Some sort of infection had occurred at the region of incision. The photograph shown in Fig. 4, *B*, was taken March 2, 1920. The bird was at this time completely cock-feathered as best seen in the feather chart Fig. 5. Here three feathers from each region are shown. The first (*a*, *b*, *c*, *d*) are those present on June 16, when the first operation was performed. They are typical for a hen-feathered bird of this age. The change that took place before the second operation can be seen from inspection of the second set of feathers (*a*¹, *b*¹, *c*¹, *d*¹, Sept. 15). The third set of feathers (*a*², *b*², *c*², *d*²), pulled out March 3, 1920, show that no further change had taken place; in fact there is some evidence of slight retrogression, which is sufficiently accounted for by the continued growth of the pieces of the testis that had been left. When killed on May 8, there were found three small sacks filled with black material on the right side, and one good but small piece of testis on the right side somewhat larger than a pea.

The third bird had been picked out of the flock, because its secondary plumage, that was just coming in, showed on the back and saddle, marked indications of cock-feathering (Fig. 6 *A*). It was obviously an exceptional bird. It was not operated on when the other two were. During June and July, as new feathers came in, this bird became more markedly cock-feathered, as seen in the photograph taken Sept. 9 (Fig. 6, *A*). Nevertheless none of the feathers were as fully developed as would be expected in a normal cock-feathered male of this race, as seen by comparing Figs. 5 and 7. The comb of this bird remained small at first, but slowly got larger. It was much paler than the comb of the normal hen-feathered males of its race and not quite so large. On Sept. 13 the bird was etherized and opened at the side between the last pair of ribs as in the ordinary process of castration. Both testes in this bird were little advanced beyond the juvenile stage, and were not nearly as large as expected in a bird of this age and size. In this condition we find, I think, an

explanation of the appearance of cock-feathers. Something had kept back the normal growth of the testes, and their small size was insufficient to entirely suppress the cock-feathering that the genetic complex of the bird called for. The testes were sectioned and studied by Dr. José Nonidez who furnishes the following report. "The luteal cells are very abundant in the spaces

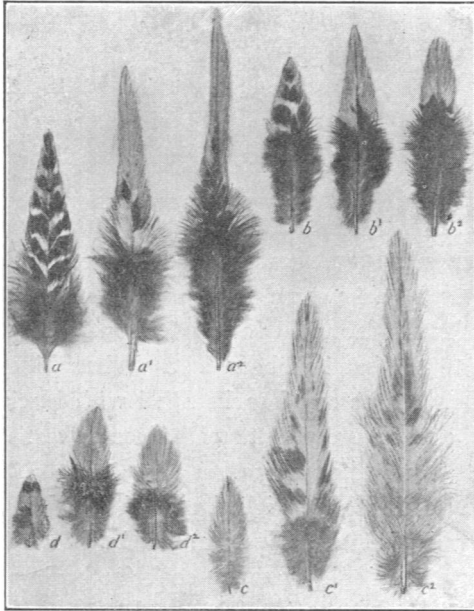


FIG. 7. Feathers of Fig. 6, *a*, *b*, *c*, *d*, before castration June 17, 1919; *a*¹-*d*², at the time of castration Sept. 13; and *a*²-*d*², March 2, 1920.

between the tubules especially in the periphery of the testes. In the clusters of luteal cells, however, most of them appear to be undergoing degeneration, for, the nuclei are a good deal shrunk and the protoplasm has lost its round vacuoles, and is changed into a clear space around the nucleus, hence the clear appearance of the clusters made up of such degenerating cells. Extreme cases of degeneration are found here and there, the nucleus having lost all its structure. On the other hand, normal or nearly normal cells are not rare; they are found in clusters containing degenerated cells; hence the appearance of the latter can not be attributed to defective preservation."

After castration this bird continued, as would be expected under any circumstances, to develop cock feathering. Its condition on Nov. 12, 1919, is shown in the photograph Fig. 6, *B*. The condition of the bird on March 6, 1920, is shown in Fig. 6, *C*. It was completely cock-feathered, but its comb was two thirds full size. The condition of the feathers is shown in Fig. 7, a^2 , b^2 , c^2 , d^2 . Before the operation June 17 the feathers were intermediate in character (a , b , c , d). The back and saddle feathers were somewhat pointed and the barring broken. After the operation (Sept. 13) the feathers that came in changed completely so that the bird became strictly cock-feathered. On

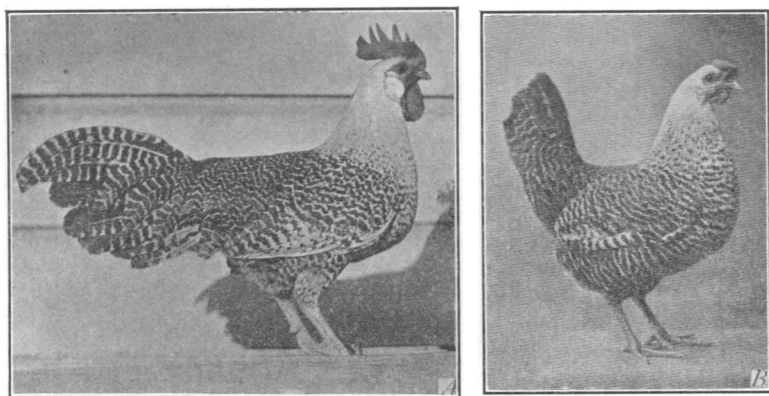


FIG. 8. *A*, normal hen-feathered male nearly one year old from the same flock as those operated on; *B*, Campine hen from Wright's "New Book of Poultry."

March 2, 1920, the change was complete (a^2 , b^2 , c^2 , d^2). The bird was killed on March 6, 1920. Three very small pieces of testis were found on the right side; none on the left. The comb measured three and a half inches long and two inches high.

Dr. Nonidez has sectioned the pieces of the testes and makes the following report. "The histological study of the three small pieces found in the region of the old testis showed that they are undergoing regeneration. The condition of the seminal tubules in these pieces contrasts with that of the tubules in the testes removed at the time of castration. While in the latter only spermatogonia occur in the tubules, in the regenerating testis the

normal spermatogenesis had started and all the stages, from the spermatogonia to mature spermatozoa, could be observed in the slides. The spermatozoa finally degenerate and this is probably due to the lack of an outlet in the organ. New tubules are arising near the surface of the section. The clusters of luteal cells, however, have apparently disappeared, their place being taken by the ordinary connective tissue and an enormous number of small lymphocytes which are arising in the intertubular tissue at this time. Some of these small lymphocytes become transformed into large wandering cells which usually occur in the testis of both hen- and cock-feathered birds. The disappearance of the

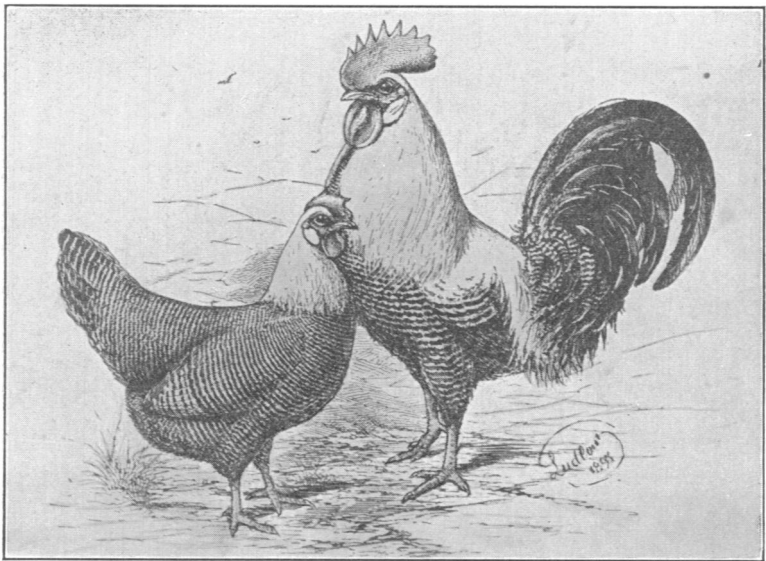


FIG. 9. Cock-feathered, normal cock and hen, from Wright's "New Book of Poultry."

luteal cells may be accounted for by the failure of this tissue to regenerate owing to its more or less abnormal condition at the time of castration. If some of the cells found in the sections are really luteal cells their numbers are probably too small to induce any change in the characteristics of the plumage. The relatively large size of the comb in the 'larger' bird, on the other hand, may be due, even in the case in which a very small

piece of the testis has been left, to the influence of a secretion other than that produced by the luteal cells."

An adult cock of the stock from which my young males came is photographed in Fig. 8, *A*. For comparison I have introduced a figure of a Campine female from Wright's "New Book of Poultry" Fig. 8, *B*. Except for the neck feathers, the plumage of these two birds is barred throughout. The peculiarities of the barring in different regions can best be seen in the single feathers (Fig. 3, *a-d*).

The tail coverts of the hen-feathered cock are barred and longer than those of the hen. In this breed these feathers are

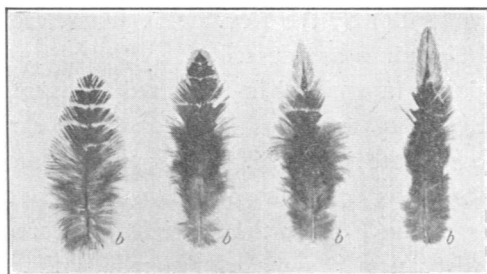


FIG. 10. Four feathers from back of a hen-feathered Campine cock of another flock. Three of the feathers show indications of cock-feathering.

not so much kept down as they are in the Sebright. The saddle feathers of the hen-feathered male are also fairly long, but broad and rounded at the end and are without hackles. The shoulder and wing bow are barred and without hackles.

The cock-feathered Campine male is shown in Fig. 9, from Wright's book. The long white neck feathers, the white back and rump feathers (both kinds pointed and with hackles), the black tail coverts, and the white shoulder are points in which the cock-feathered differs from the hen-feathered bird, and are exactly the same features that appear when the hen-feathered male is castrated.

GENERAL CONCLUSIONS.

It has been shown in the Sebright that hen-feathering is inherited. When crossed to a cock-feathered race (Game Bantams) all F_1 birds are hen-feathered, though some of them not

as completely so as the Sebright. Still there is no overlapping with the cock-feathered type. The F_2 and the back-cross cocks are either hen-feathered or cock-feathered; the former showing about the same range of variability as the F_1 cocks. The failure of perfect dominance in some of the F_1 and F_2 cocks may indicate that the heterozygote has a wider range (the gene not completely dominant), or that subsidiary genes introduced from the cock-feathered birds allow a wider range of variability of the character. Only an extended series of experiments can settle this point.

In the Campines also there is evidence that the gene for hen-feathering is inherited and dominant. In a paper published several years ago (1914) by the Rev. E. L. Jones, crosses between two races of Campines are described, one of them belonging to a race (Belgium) in which hen-feathered birds are the recognized standard, the other (English) belonging to a race in which cock-feathering is the standard. The evidence seems to show that hen-feathering is dominant, also that there is segregation in the back-cross, and in F_2 as in the Sebrights. There are however serious inconsistencies in some of the results that may be accounted for on the assumption that the hens of the cock-feathered race were not pure for the character-pair in question;—an assumption that does not seem too improbable, when one recalls that the latter, the dominant type, has often been mixed with cock-feathered strains. Whether the gene for hen-feathering is the same as that in the Sebrights can, of course, only be determined by crossing the two breeds. From what I have heard it appears that in this country the Campines, even when said to be pure for hen-feathering, are not so “fixed” as are the Sebrights; for, the latter do not “break” as do the Campines unless castrated, while the Campines are reported to show quite often a few or many cock-feathers. It is recognized that when sick or in poor condition such feathers appear and may be replaced later by hen-feathers if the bird recovers. I have some feathers from an old bird of another strain, purporting to be pure for hen-feathering, that show unmistakable changes in the direction of cock-feathers (Fig. 10). At the time the bird had been confined and was in poor condition. This difference in the two races

might be due to different factors, or, as seems more probable, due to the less complete dominance of the gene in the Campines (in conjunction with the rest of the hereditary complex). Possibly different modifying genes are present that fortify the action of the main gene in the Sebright. Further experiments will, I hope, settle this question.

The possible influence of other endocrine secretions must also be examined, because in mammals there is some evidence that other organs than the gonads may produce effects on the secondary sexual characters. Since the pituitary gland is one of the internal glands that, par excellence, affects growth, I have examined its condition in the three Campines and compared the organ with that in one normal hen-feathered bird of the same race. In general there is little if any difference in size between the pituitary in the normal and castrated birds; but it appears to be slightly larger in the castrates, more especially the part inclosed in the sella turcica. Since I had only one normal bird for comparison, this difference may be purely accidental; but the observation justifies further search on more ample material. Moreover, accurate measurements of the gland will be necessary before any value can be attached to such findings.

It should be recorded, perhaps, that the kidneys in the smallest and most completely castrated bird are reduced in size, but whether this bird was abnormal in this respect can not be stated.

I have not observed any change in the suprarenals in the castrated birds.

It is also interesting to note that the removal of the testes of cock-feathered birds (to produce capons) causes in them also some slight changes in the same secondary sexual characters in which they differ from hen-feathered birds. The neck and saddle feathers of the capon become longer, as do also the longer wing coverts (Goodale, Morgan). It appears, then, that even in the cock-feathered birds there is some inhibition to the growth of these feathers produced by the normal testis. This inhibition may be supposed to go so far in the hen-feathered races as to completely stop down the male plumage to that of the hen. The plumage of the hen, too, is known to be inhibited by the ovary; for, when the ovary is removed she develops the full cock-

feathering characteristics of the male of her race (Goodale). Elsewhere I have discussed how these effects are brought about—whether the same kinds of secreting cells are present in the ovary and in the testes of the hen-feathered males. This question is being further studied at present and need not be considered here.

The comb and wattles are the most remarkable secondary sexual characters of the cock. Their condition is a close index of the condition of the gonad. In fact, after castration their size and the amount of blood present in them indicates how far the gonad has been removed. Even a very small piece of the testis suffices to cause them to grow to their full size. This is well shown in the pictures of two of the Campines described above, in which the comb became reduced shortly after the operation, and then slowly grew almost to its full size in the course of the following months. Its paleness showed, however, that the testes were not normal in size, and this was confirmed by autopsy. When the birds were killed a small piece of the testis was found. In the hen, too, it appears that the ovary has an inhibitory influence on the comb and wattles; for, as Goodale has shown they become larger in the ovariectomized birds. Since the testes of the normal full-grown cock-feathered bird seem deficient, or lacking in luteal cells (Boring and Morgan) it may appear that these cells do not produce the endocrine secretion that affects the comb, although if it can be shown that they do not completely disappear even in adult cock-feathered birds it may be that a much smaller amount of this secretion than is essential for suppressing the cock-feathering suffices to cause the enlargement of the comb and wattles. But if, as is said to be the case, the luteal cells disappear entirely in the adult cock-feathered bird, then there must be some other element in the testis that maintains the comb and the wattles at their maximum size. Here again is a further field for investigation.

BIBLIOGRAPHY.

Boring, Alice M.

- ¹² The Interstitial Cells and the Supposed Internal Secretion of the Chicken Testis. *Biol. Bull.*, XXIII.

Boring, Alice M., and Pearl, Raymond.

- '17 Sex Studies, IX. Interstitial Cells in the Reproductive Organs of the Chicken. *Anat. Record*, XIII.

—, Alice M., and Morgan, T. H.

- '18 Luteal cells and Hen-feathering. *Jour. Gen. Physiol.* I.

Goodale, H. D.

- '10 Some Results of Castration in Ducks. *BIOL. BULL.*, XX.
 '10 Breeding Experiments with Poultry. *Proc. Soc. Exp. Biol. and Med.*, VII.
 '11 Studies in Hybrid Ducks. *Journ. Exp. Zool.*, XX.
 '13 Castration in Relation to the Secondary Sexual Characters of Brown Leghorns. *Am. Nat.*, XLVII.
 '16 A Feminized Cockerel. *Journ. Exp. Zool.*, XX.
 '16 Gonodectomy. *Carnegie Inst. Wash. Pub. No.* 243.

Hunter, John.

- 1780 Account of an Extraordinary Pheasant. *Phil. Trans. Royal Soc. London*, LXX.

Jones, E. L.

- '14 The Campine Club, 1914, Year Book (see also *Farm Poultry*, June, 1914, p. 113).

Lefevre, G.

- '16-'17 Sex-limited Inheritance in Poultry. *Anat. Record*, XI, p. 499.

Morgan, T. H.

- '13 Heredity and Sex. New York.
 '15 Demonstration of the Appearance after Castration of Cock-feathering in a Hen-feathered Cockerel. *Proc. Soc. Exp. Biol. and Med.*, XIII.
 '17 The Theory of the Gene. *Amer. Natur.*, LI.
 '17 Goodale's Experiments on Gonadectomy of Fowls. *Sci.*, XLV.
 '17 Demonstration of the Effects of Castration of Sebright Cockerels. *Proc. Soc. Exp. Biol. and Med.*, XV.
 '19 The Genetic and Operative Evidence Relating to Secondary Sexual Characters. *Carnegie Inst. Wash. Pub. No.* 285.